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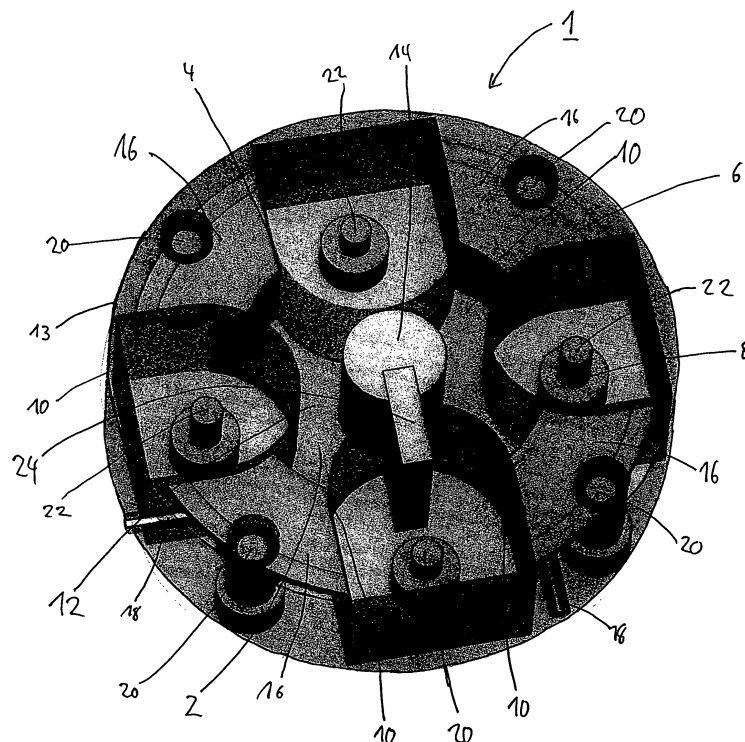
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(54) **Resonator system**

(57) A resonator system (1) comprising a hollow cavity with a conducting surface (13) and a number of inner conductors (10) inside said hollow cavity shall be provided, which features a specifically simple and space saving design and also facilitates manufacturing. To achieve

this, said inner conductors (10) are arranged around the centre of said hollow cavity with a nonzero distance to said conducting surface (13), and each of said inner conductors forms an individual resonator (2, 4, 6, 8) with said conducting surface (13).



FIG

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Description

[0001] The invention relates to a resonator system comprising a hollow cavity with a conducting surface and a number of inner conductors inside said hollow cavity.

[0002] An electromagnetic resonator usually consists of a hollow space with conducting boundaries, into which an electromagnetic signal is coupled. The electromagnetic waves of the signal then travel back and forth inside the resonator and are multiply reflected. Due to the superposition behaviour of electromagnetic waves, specific frequencies are amplified because the dimensions of the resonator are an integral multiple of the wave length at those frequencies. A transverse electromagnetic (TEM) wave inside the resonator is produced at these specific frequencies, while other frequencies are suppressed. Resonators are therefore usually used to select specific frequencies from the signal.

[0003] Resonators are often used in ultra high frequency (UHF) and microwave technology, e. g. in mobile phone services. They are used in high power amplifiers to filter and extract the desired signal out of the bulk of signals received in the antenna. A particularly effective high power amplifier is a so-called feed forward design which typically includes one or more delay lines that equalize delay variations across the different frequency bands. Especially in this configuration, coaxial delay line filters are often used to realise group delay required for intermodulation product cancellation to increase power amplifier linearity and efficiency.

[0004] Another important application of resonators in the context of UHF and microwave technology are duplex filters or duplexers. Usually, radio antennae work in full duplex, meaning they both send and receive signals. Here, the transmitted and received signals shall be usually separated or filtered for further processing. Because of their high performance, this is very often done by coaxial resonators, i.e. resonators with coaxially arranged inner and outer cylindrical conducting surfaces.

[0005] To achieve the desired frequency filter behaviour of the resonator, a number of different resonator designs is known. For example, a capacitively loaded short circuit stub can be constructed where the stub conductor can have different shapes and capacitive loading enables to shorten the resonator length for the same resonant frequency of the resonator.

[0006] Also previously known is the use of tuning screws in the adjusting of the natural frequency of a resonator. A part of the resonator is equipped with a metal screw at its inner side. Changing a screw position influences the electromagnetic field in the cavity and the natural frequency of the resonator changes.

[0007] To achieve a certain desired number of allowed frequencies - also called the passband of the resonator or resonator filter - several resonators can be coupled. In this context, this means that electromagnetic field is coupled to neighbouring resonators appropriately enabling to adjust the desired passband.

[0008] However, in the case of coupling several resonators, the number of components in the filter increases and also the number of work steps to build the resonator is increased. Also, in certain applications, there might be a limited geometrical space available which may result in problems concerning the size of the coupled resonator system.

[0009] Thus, the object of the invention is to provide a resonator system of the above kind, which features a specifically simple and space saving design and also facilitates manufacturing.

[0010] This object is achieved according to the invention by a resonator system, wherein said inner conductors are arranged around the centre of said hollow cavity with a nonzero distance to said conducting surface, and wherein each of said inner conductors forms an individual resonator with said conducting surface.

[0011] The invention is based on the idea that a simple design and facilitated manufacturing of a resonator system would be possible, if the number of parts used in the manufacturing process could be reduced. However, the number of parts for each resonator is not reducible without influencing the function of the resonator. Thus, a reducing of the number of parts could only be done by combining parts of several resonators by using a single part in several resonators at the same time. Especially the conductors that reflect the electromagnetic waves in the resonator could be used in such a way since those conductors are already short-circuited and thus conductively connected already. This means that one conductor could be used for a number of resonators in the resonator system. This is possible by arranging the inner conductors belonging to each individual resonator inside a hollow cavity with a conducting surface, the conducting surface serving as a conductor common to all resonators.

[0012] In an advantageous embodiment, the resonator system comprises a central conductor in the centre of said hollow cavity. This short-circuited central conductor or stub can be used to prevent unwanted nonadjacent couplings and ensure their better control.

[0013] In another advantageous embodiment, said central conductor features a number of grooves and/or holes to allow for cross couplings between said resonators. Nonadjacent resonators naturally have a weaker coupling to each other as the geometric distance between them is larger. To allow couplings between such resonators nonetheless, grooves and/or holes in the central conductor equipped with suitable coupling loops and/or antennae or chamfering the central conductor can allow for coupling those resonators desirably.

[0014] Advantageously, the resonator system comprises a conducting support plate, wherein said inner conductors are arranged on said support plate and, if applicable, said central conductor is placed on the centre of said support plate. Such a conducting support plate provides the short-circuiting of the conductors and also facilitates manufacturing, as the positions of the conductors can be adjusted easily.

[0015] A specifically simple design is possible by arranging the conductors symmetrically. Therefore, the inner conductors are advantageously arranged equidistantly in circumferential direction and/or with respect to the centre of said hollow cavity.

[0016] In another advantageous embodiment, said inner conductors are formed as sections of a coaxially arranged hollow cylinder and/or, if applicable, said central conductor is shaped cylindrically. This configuration allows for an especially simple design, since for the manufacturing of the individual conductors a single hollow cylinder can be cast and then cut into different pieces to form the individual conductors of each resonator. The resonator could also be cast completely with properly shaped individual conductors. Also, the central conductor can be easily manufactured as a central stub of cylindrical or other shape.

[0017] Due to the nature of the design of the resonator system, adjacent resonators are coupled appropriately. To realise the required or prevent unwanted cross couplings between neighbouring resonators, at least one radial shielding fin is advantageously arranged between a number of said individual conductors. A shielding fin or a coupling element can also be a part of the hollow cavity.

[0018] To adjust the natural frequency of a resonator, tuning screws changing the capacitance between the two conductors of the resonator can be used. Therefore, in an advantageous embodiment a number of tuning screws are arranged between a number of said inner conductors. With these tuning screws the frequency of each individual resonator of the resonator system can be adjusted.

[0019] In a further advantageous embodiment of the resonator system, an appendix extending radially away from the centre of said hollow cavity is attached to said inner conductors, which extends to the outside of the resonator system and thus allows a capacitive loading and an easy external coupling for the several applications of the cavity resonator system. To make it possible to adjust the loading of each resonator to the proper frequency, a number of tuning screws are arranged such that they can penetrate said appendices.

[0020] In a further advantageous embodiment, an electrode of a capacitor is connected to the inner conductor or to the appendix for capacitive coupling of an external electromagnetic signal. This allows for a specifically convenient input coupling of the cavity resonator system to an external electromagnetic signal source.

[0021] The advantage of the invention relates to the fact that by arranging said inner conductors are around the centre of said hollow cavity with a nonzero distance to said conducting surface, thus forming an individual resonator from each of said inner conductors with said conducting surface, an especially simple, convenient and compact design of a cavity resonator system is possible while at the same time considerably facilitating the manufacturing process. Also, the topology of the cavity resonator system enables to apply volume production tech-

nologies very effectively because of the simple design that makes it possible to realise very reproducible couplings and to shorten the required tuning time of the resonator. Also, the number of parts used in the manufacturing process is reduced and the number of machined cavities is smaller, the cavities are bigger and shallower which is also much easier to silver plate, which considerably reduces the manufacturing costs of the filter. Furthermore, due to compact design of the resonator structure a very repeatable performance is achieved compared to the conventional design.

[0022] An exemplary embodiment of the invention is described in detail in the enclosed drawing. The figure shows a resonator system with a four inner conductors arranged in a hollow cavity, forming the different resonators with the conducting surface of said hollow cavity.

[0023] The resonator system 1 according to the figure comprises four resonators 2, 4, 6, 8. Each of these resonators has an inner conductor 10 that is placed on a support plate 12. The system of conductors and support plate is put into a hollow cavity (not explicitly shown) with a surrounding conducting surface 13.

[0024] In the centre of the support plate 12, a central conductor 14 is placed providing a grounding electrode to all circumambient resonators that enables better controlling of adjacent and preventing of nonadjacent couplings. The central conductor 14 could also be a part of the hollow cavity. Introducing coupling elements between two resonators, the coupling between them can be modified. Additional conductors 14 could also be placed on the support plate 12 providing more grounding electrodes to circumambient resonators to control couplings in a multiplet resonator system.

[0025] Each of the individual conductors 10 has an appendix 16 extending radially away from the centre of the cavity resonator system 1 which extends to the outside of the resonator system 1 which realises required capacitive loadings of the resonators and makes it possible to conveniently couple the resonator system 1 to an external electromagnetic source. Here, the external coupling is done by single layer capacitors 18, whose first electrode is conductively connected to the appendices 16 and whose other electrode is connected to the external source. Other coupling techniques as tap, inductive loop, or capacitive antenna can be used where appropriate.

[0026] The resonators 2, 4, 6, 8 are shaped such that the conductors of the resonator system 1, comprising the central conductor 14, the support plate 12 individual conductors 10 with appendices 16 can be cast as one single piece of metal or of another metalized material which is ready to be assembled to the hollow cavity. The coaxial shape also allows for turning the part as one single piece of metal or other metalized material.

[0027] For a precise tuning of resonating frequencies of individual resonators 2, 4, 6 and 8, the cavity resonator system comprises a number of tuning screws 20 that can penetrate the appendices 16. To influence the coupling between the separate resonators 2, 4, 6 and 8, a further

set of tuning screws 22 is arranged between the resonators 2, 4, 6 and 8. The tuning screws 22 influence the electromagnetic field between the resonators 2, 4, 6 and 8 and thus can be used to precisely tune the desired coupling properties of the resonator system 1.

[0028] To prevent unwanted coupling between certain resonators, a shielding fin 24 extending radially from the central conductor 14 is placed between the resonators 2 and 8. The shielding fin is conductively connected to the central conductor 15 and therefore prevents electromagnetic coupling between those two resonators 2, 8. In case there are stronger couplings desired, it would also be possible to put a number of grooves and/or holes into the central conductor 14, for example to make it possible to directly couple non-adjacent resonators or strengthen the coupling between adjacent resonators.

[0029] The design shown in the figure shows a very simple and compact way to construct a quadruplet resonator system 1 which is also very convenient to manufacture as it can be manufactured essentially as one piece. Also, the resonator system 1 is very conveniently and reproducibly tuneable to the desired frequencies as needed in the specific application. Multiplet resonator systems can be realised and two or more such systems can be cascaded in specific applications.

Reference numerals

[0030]

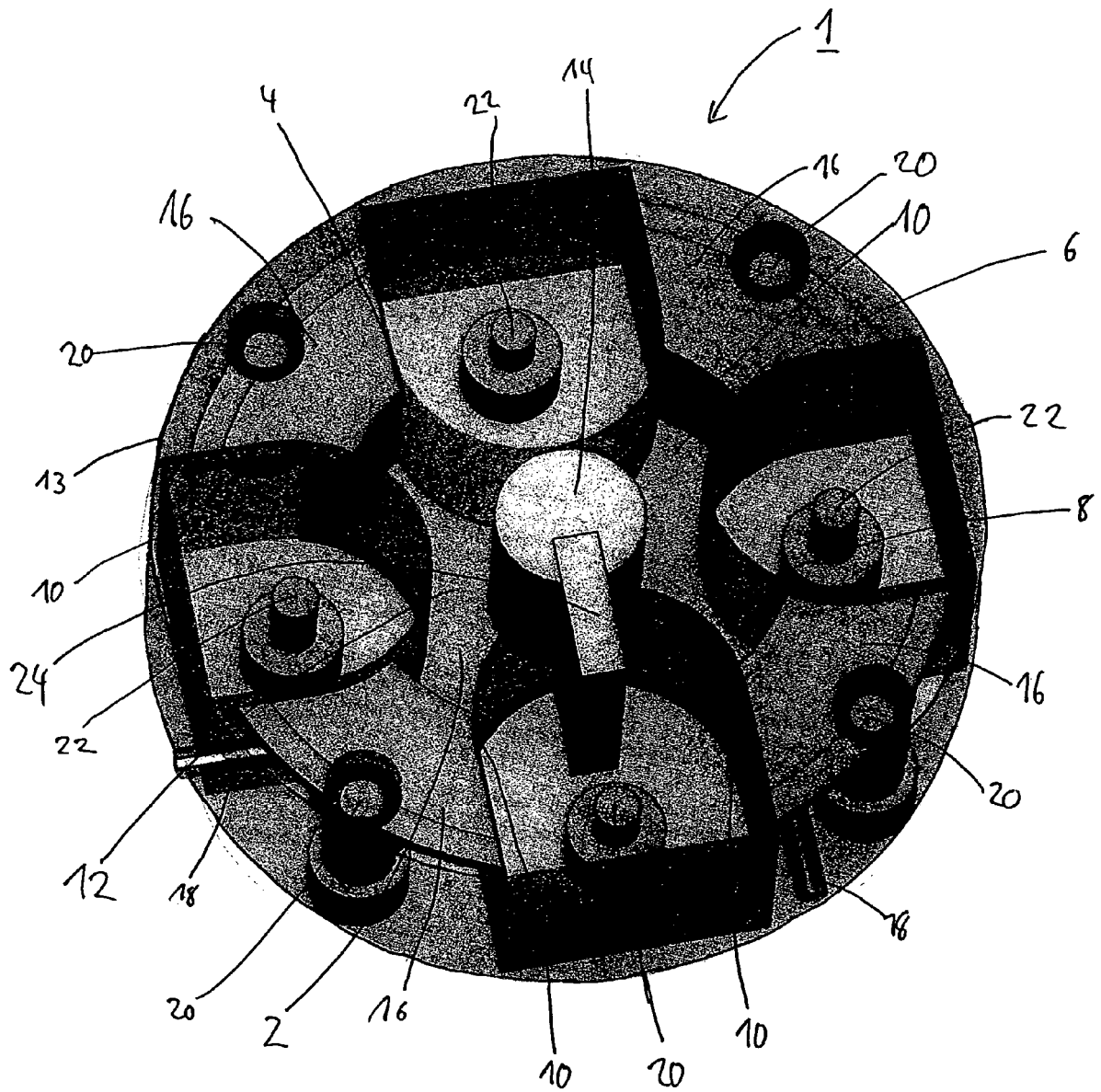
1	resonator system
2, 4, 6, 8	resonators
10	inner conductor
12	support plate
13	conducting surface
14	central conductor
16	appendix
18	capacitors
20, 22	tuning screws
24	shielding fin

Claims

1. A resonator system (1) comprising a hollow cavity with a conducting surface (13) and a number of inner conductors (10) inside said hollow cavity, wherein said inner conductors (10) are arranged around the centre of said hollow cavity with a nonzero distance to said conducting surface (13), and wherein each of said inner conductors forms an individual resonator (2, 4, 6, 8) with said conducting surface (13).
2. The resonator system (1) according to claim 1, comprising a central conductor (14) in the centre of said hollow cavity.
3. The resonator system (1) according to claim 2,

wherein said central conductor (14) features a number of grooves and/or holes to allow for cross couplings between said resonators (2, 4, 6, 8).

4. The resonator system (1) according to one of the claims 1 to 3, comprising a conducting support plate (12), wherein said inner conductors (10) are arranged on said support plate (12) and, if applicable, said central conductor (14) is placed on the centre of said support plate (12).
5. The resonator system (1) according to one of the claims 1 to 4, wherein said inner conductors (10) are arranged equidistantly in circumferential direction and/or with respect to the centre of said hollow cavity.
6. The resonator system (1) according to one of the claims 1 to 5, wherein said inner conductors (10) are formed as sections of a coaxially arranged hollow cylinder, and/or, if applicable, wherein said central conductor (14) is shaped cylindrically.
7. The resonator system (1) according to one of the claims 1 to 6, wherein at least one radial shielding fin (24) is arranged between a number of said inner conductors (10).
8. The resonator system (1) according to one of the claims 1 to 7, wherein a number of tuning screws (22) are arranged between a number of said inner conductors (10).
9. The resonator system (1) according to one of the claims 1 to 8, wherein an appendix (16) extending radially away from the centre of said hollow cavity is attached to said inner conductors (10), and wherein a number of tuning screws (22) are arranged such that they penetrate said appendices (16).
10. The resonator system (1) according to one of the claims 1 to 9, wherein an electrode of a capacitor is connected to said inner conductor (10) or to said appendix (16) for capacitive coupling of an external electromagnetic signal.



FIG



EUROPEAN SEARCH REPORT

Application Number
EP 08 00 9219

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Place of search The Hague		Date of completion of the search 3 October 2008	Examiner Pastor Jiménez, J
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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